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OPERATIONAL CAPABILITY OF A WEATHER RADAR TIME LAPSE COLOR DISP--ETC(U)
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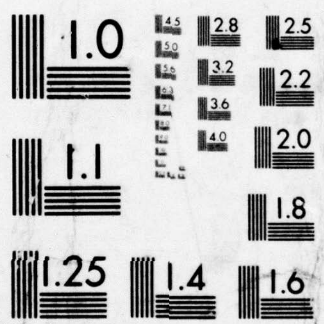

MICROCOPY RESOLUTION TEST CHART
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OPERATIONAL CAPABILITY OF A WEATHER RADAR TIME LAPSE COLOR DISPLAY SYSTEM

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1. INTRODUCTION

The Weather Radar Processor and Display was engineered and fabricated by the Raytheon Company, Sudbury, Massachusetts in accordance to specifications prepared by the Weather Radar Branch of AFGL. This work was performed as part of a continuing effort to develop new instrumentation and techniques to satisfy AWS weather radar requirements in the 1980's. The specific objectives of this development were: to evaluate the use of color to display echo intensities in time lapse for self briefing displays; to evaluate various azimuth resolutions to determine the optimum for transmission of pertinent meteorological information to remote sites with a minimum of redundancy and lastly to permit evaluation of a technique of processing radar data in polar coordinates to preserve maximum radar resolution.

2. SYSTEM DESCRIPTION

The Weather Radar Processor and Display (WRPD) consists of a mini computer with 16K core memory, a moving head disk with a storage capacity of 1,280,000 16 bit words, a logic assembly and a color display monitor.

The mini computer under operator control via teletype keyboard interacts with the logic assembly to cause various formats, resolutions and color thresholds to be processed and displayed on the color monitor simultaneous with continuous radar acquisition as commanded by the operator.

The disk provides the storage for software programs as well as for 40 pictures in polar form. Six bits of video for each of 100 range cells by 256 azimuth sweeps is stored for each picture. In addition, a second image for each picture is stored which contains the two bits of threshold converted video used for display.

The mini computer stores the pictures on the disk, creates the display image and controls the sequencing of data for display according to operator instructions.

The WRPD accepts digitized echo intensity data from an external radar signal integrator and stores this data in a manner that enables the user to view up to 40 complete PPI's. These PPI's are displayed in four operator selected threshold levels and are presented in green, blue, red and black. The system can acquire a finite number of from one to forty pictures or can continuously capture pictures. Pictures can be captured at an interval of from 30 seconds to 10 minutes in steps of one half second. Angular resolution can be increased by processing the total number of azimuth sweeps (256) in sector widths of 90°, 180°, as well as 360°.

Any sequence of previously acquired pictures can be automatically displayed at a rate of from one half second to five seconds per frame in steps of one half second. In addition, the automatic time lapse sequence mode can be interrupted to display a single picture and then continue picture presentation either forward or backward in time sequence. If previously acquired pictures are not being displayed, newly acquired pictures are displayed in real time.

The pictures are displayed on a standard 19 inch color TV monitor. A sequence of color photographs of the monitor are shown on Fig. 3. In addition to the PPI data, eight lines of six character alphanumerics are displayed. The threshold intensity level for each color and ISO threshold appears in the top right block. The ISO is a misnomer and actually means that any signal above the given threshold will be blanked and will appear as a black area surrounded by red. In the bottom right block appearing line by line is the date, the time of picture capture, the frame number and the present time.

Three equidistant range rings appear for the maximum range selected, namely, 240, 120, 60, or 30 km. In the illustration, the selected range is 120 km so that each range represents 40 km.

3. POLAR COORDINATE STORAGE

A unique feature of the WRPD is that it stores all picture data in polar form. This results in a memory savings of 2:1 over storing the images in rectangular form for the same image quality. This becomes apparent if one considers that in the WRPD we store 256 azimuths with each azimuth composed of 100 range elements resulting in a total of 25,600 elements. Storage for a TV coordinate system would require 225 x 225 or 50,625 elements of storage. An additional advantage of polar form handling could be realized if transmission of radar pictures becomes necessary. The polar form data would be transmitted instead of a line by line TV scan resulting in a 2:1 element savings as above.

Polar form data is converted to a TV format by an on the fly scan conversion technique which is graphically illustrated by Fig. 1. The azimuth lines and range arcs border the azimuth/range elements which are stored in the refresh memory via the mini computer. Each element contains one of four intensity levels which will be represented by a color or a blank. The coordinate conversion program uses a table of vectors (stored in the control memory of the mini computer) to sequence through the refresh memory so that the correct azimuth/range video is assigned into the appropriate TV cell as each line is processed. The TV cells are depicted as circles in the illustration

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with each circle assuming one of three colors or a blank arbitrarily illustrated by cross hatching. In short, each circle is assigned (through the table of vectors) to an azimuth/range element. In the case of overlap, TV cells will assume the color of the element intercepted by the greater portion of the circle.

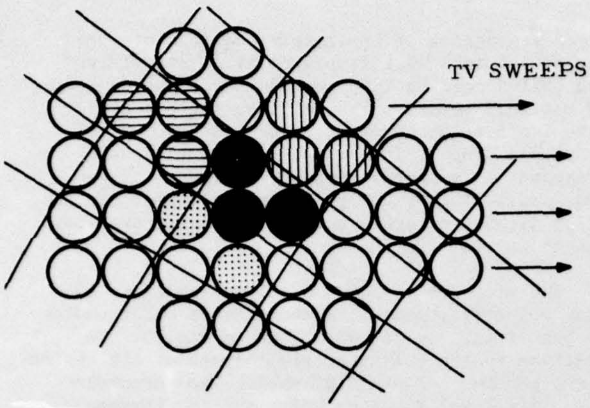

Figure 1. On the fly scan conversion technique.

4. SYSTEM CONSIDERATIONS

The WRPD is presently interfaced to a Digital Video Integrator of the type described by Glover (1972). This integrator processes logarithmic video from a CPS-9 radar and provides range normalized eight bit data to the WRPD. All but the two lowest bits are utilized by the WRPD to process the 64 levels of intensity data.

Meaningful interpretation of the display requires a system calibration which relates the color threshold values displayed by the alphanumerics to a basic radar parameter such as the equivalent radar reflectivity factor. These numbers represent one of the 64 levels of intensity data and will be referred to as LSBs (Least Significant Bits).

The relation of received power to intensity level is a function of the integrator and is adjusted to maintain a slope of $\frac{100 \text{ db}}{64 \text{ LSB}}$. The system is calibrated by feeding a known signal at a given range through a horn to the antenna and reading the digitized output of the integrator in LSBs. A value for the equivalent radar reflectivity factor Z_e can be determined by means of the basic radar equation $Z_e = \frac{P_r\ (r^2)}{R_c}$ where P_r is the test signal, r the range in km and R_c is the radar constant. From these relationships, a nomogram relating LSBs to dBZ may be plotted as shown in Fig. 2.

5. OPERATIONAL TECHNIQUES

The WRPD's variety of operating modes were investigated in a number of diverse storms to assess its capability as an operational tool. The optimum choices of angular resolution, range

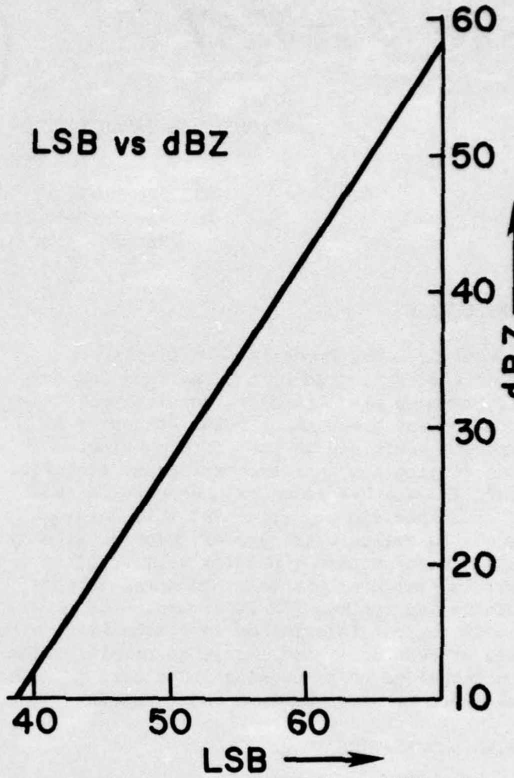

Figure 2. Nomogram showing LSB vs. dBZ. The slope is fixed at $\frac{64 \text{ LSB}}{100 \text{ dBZ}}$.

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resolution, rate of picture acquisition, rate of picture display and color thresholding were determined.

The apparent visual difference in the display of weather data stored with minimum angular resolution (256 azimuth segments in 360°) versus maximum resolution (256 azimuth segments in 90°) was not noticeable with the display in time lapse playback. A difference in fine structure was apparent only if the display was halted and then only for convective storms. It was concluded that in general situations, the motion information obtained from the time lapse display supersedes the necessity of displaying information in finer detail and thereby increasing the storage capacity requirements of the system.

The range resolutions used are either 0.3, 0.6, 1.2, or 2.4 km as selected by the operator. Although the resolution of even the longest range is acceptable, improved resolution will be realized as the storms approach the station and shorter ranges are selected.

The rate of picture acquisition is determined primarily by the rapidity of weather development and the range selected for display. Typically, in the winter, acquisition intervals of 5 minutes for the 240 km range and 3 minutes for the shorter ranges are selected. The interval selected must be of sufficient length to resolve distinct motion during playback. An interval that is too lengthy will result in a jumpy playback and a loss in continuity of identifiable features in a weather pattern. A sequence of 4 pictures of a snow shower

situation is shown on Fig. 3. The frames show the movement of the storm at intervals of 6 min. The storm's speed is determined using the 40 km range rings as a reference and noting the distance of cell travels during the given time interval.

The picture playback mode is dependent on the information desired by the operator. The fastest playback interval of one frame every 0.5 seconds provides the smoothest visual display and is best to ascertain the direction of echo motion and the trend of echo growth or decay. Echo speed is best determined by choosing two discrete frames which are separated in time by a longer interval such as 15 min. and playing only these two frames back at a 2 second per frame rate. This rate is slow enough for one to measure with the aid of the displayed range marks, the distance an echo has moved and thus compute its velocity. In most operational situations, the system would be directed to operate in a mode where the frames would be played back continuously while new PPI's were being acquired. This mode enables a continuous update of the data as well as a 39 frame history of the weather situation. A playback interval of 1 second per frame appears to be a good compromise for operation in this mode.

The color thresholds defined for a sequence of pictures, can be redefined for the same sequence since all 64 intensity levels remain in storage. This capability enables an operator to go back and pick out a particular intensity level or levels that were not previously resolved and effectively extend the color display range to all 64 levels. An effective operational technique, however, is to pre-assign a color, preferably red to a relatively high intensity level that can be associated with a severe condition such as hail in the summer or heavy snow in the winter.

6. CONCLUSIONS

In its 1-1/2 years of operation during a variety of storms, the WRPD has successfully demonstrated its intended capability of a real time self briefing weather radar processor and display system. In repeated cases, the system has shown that by projecting the motion and development of weather echoes, the time of arrival of precipitation can be accurately predicted.

The azimuth and range resolutions of the system have been adequate, particularly in motion display. There are some reservations about the ability to resolve details such as hook echoes and other severe weather signatures. Too few severe storms occurred in this area during the testing period for fair evaluation of this latter capability.

The advantages of processing the radar data in polar form is debatable and not completely resolved. The issue simply stated would be to compare the cost of more complicated software, in the case of the polar form technique, to the cost of a larger memory capacity in the case of the rectangular technique.

The reliability of the WRPD was exceptional and there were absolutely no component failures during the testing period. One malfunction of the software did occur as a result of a voltage surge caused by a nearby lightning strike. The disk resident program was temporarily lost, but no permanent damage resulted.

7. FUTURE EXPANSION

By mid-August 1976, the system described will have been upgraded to provide a Constant Altitude Plan Position Indicator and a Vertically Integrated Liquid Water Content presentation in three colors and in time lapse. VILWC will be presented as an average of ground range columns generated from a stored data base during a volumetric radar scan. Reflectivity values at four distinct altitude regions will be corrected for the different states of precipitation at different altitudes.

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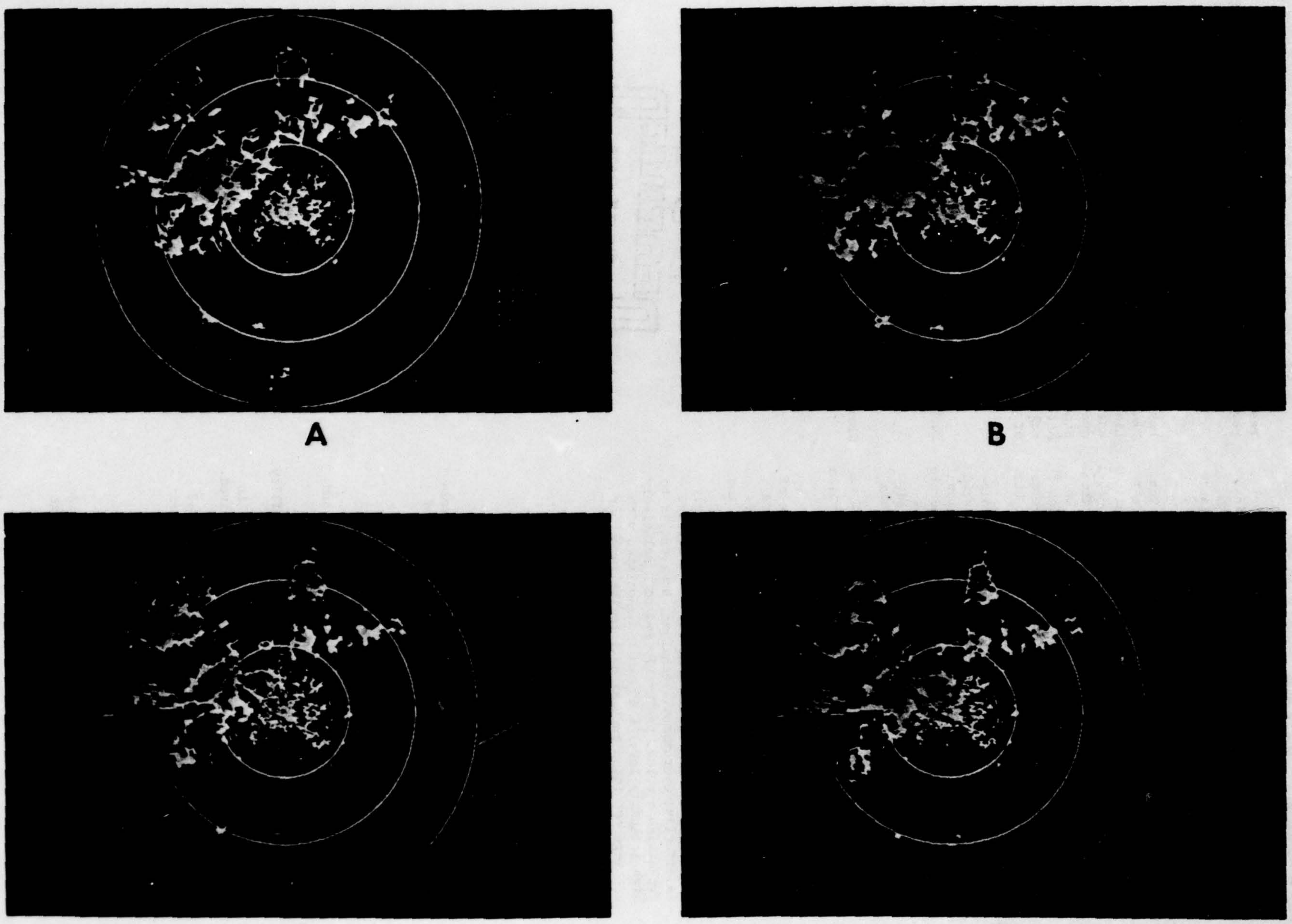

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13. ABSTRACT

A weather radar processor and color display capable of storing up to 40 complete radar PPI's and displaying these in color and in time lapse fashion has been tested at the AFGL Weather Radar Facility. Operation in various seasonal weather situations has enabled the examination of a number of system variables, such as the rate of picture acquisition, rate of picture display, color thresholding, range and azimuthal resolution and optimum combinations thereof. The real time self-briefing feature of the system will also be discussed and illustrated with still and motion pictures of a number of case studies. A brief description of the system hardware and software and a discussion of future expansion will also be presented.

KEYWORDS: Time lapse, Self briefing color, Processing

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